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Description

This invention relates to relays for protecting an electrical power transmission system comprising a two or more ended electrical feeder. In particular the invention relates to differential relays which operate to protect the system when the difference between the value of an electrical quantity, usually current, monitored at two or more different points on the feeder exceeds a predetermined amount.

In recent years differential relays have been developed which use digital data transmission to transmit the necessary data regarding the monitored electrical quantities between the monitoring points on the feeder. Such differential relays are generally more reliable and faster than relays using analog transmission. Differential relays using digital data transmission do, however, suffer the disadvantage that as digital data, unlike continuous analog signals, represent the value of the monitored electrical quantity at discrete time intervals, it is necessary that some form of synchronisation be provided so that digital data collected at different points on the feeder can be aligned to the same time instant. Known differential relays using digital data transmission solve this synchronisation problem by providing an external radio clock, but this leads to additional cost and complexity, and furthermore a suitable radio clock may not be available to all users of the power transmission system. Other known differential relays using digital data transmission solve the synchronisation problem by using a clock signal derived from the communication multiplexing equipment, but this approach suffers the problem that the derivation of the clock signal is very dependent on the actual design of the communication multiplexing equipment, the network configuration and the control hierarchy adapted: as the relay would have to work with a variety of communication equipment, the cost for developing different clock interfaces could be prohibitive. Furthermore, a clock source may not be available if the relay is to be used over a direct non-multiplexing link.

In U.K. Patent Application No. GB 2072974A there is described a differential relay using digital data transmission in which independent clocks are provided at the monitoring points along the line to be protected, the clocks defining the time intervals at which electrical data is measured at the monitoring points. Digital data relating to the current measured at a local monitoring point is transmitted to a remote monitoring point and stored in a first memory, while digital data relating to the current measured at the remote monitoring point is stored in a second memory. A shift register is arranged to shift through the data in the first memory to correct the data therein by a factor corresponding to the transmission time of the data collected at the local monitoring point between the local and remote monitoring points. The data collected at sampling times $t_1+\alpha$, $t_2+\alpha$, $t_3+\alpha$... at the remote monitoring point is then compared with the correct data collected at sampling times t_1, t_2, t_3... at the local monitoring point, where α is the time interval between the sampling times at the two points, to determine whether the relay is to operate.

Such a relay suffers the disadvantages however that in order to achieve a reasonable amount of accuracy, the sampling time interval α must be small and so a very high sampling rate must be used for the derivation of data at the monitoring point. The data transmission time must also be known and remain constant during operation.

In EP—A2—0078517 there is described another differential relay using digital data transmission in which independent clocks defining the mesuring intervals are provided at the monitoring points along the line to be protected. In this relay operation at low sampling rates is obtained by use of a polling message technique wherein a polling message is sent from a first monitoring point to a second monitoring point in response to which there is transmitted from the second monitoring point back to the first monitoring point digital data relating both to the measured quantity at the second monitoring point and its time of measurement. The time of measurement data is then utilised to synchronise the clocks at the two monitoring points and thereby enable measurement of the quantity at the two monitoring points relating to the same instant of time to be obtained for comparison.

It is an object of the present invention to provide a differential relay using digital data transmission, with independent clocks defining the time intervals at which electrical data is measured at the monitoring, and which utilises a polling message technique to allow low sampling rates, but does not involve synchronisation of the two clocks.

According to the present invention there is provided a differential relay operative to protect an electrical feeder in an electrical power transmission system in dependence on the differences in an electrical quantity monitored at different monitoring points on the feeder comprising: a respective apparatus associated with each monitoring point, each apparatus including means for deriving digital data representative of the value of the electrical quantity at the point, at time intervals defined by a respective clock within the apparatus; a digital data communication channel linking the monitoring points; and means for transmitting through the communication channel a polling message from a first said apparatus located at a first monitoring point, to a second said apparatus located at a second monitoring point, the second apparatus including means responsive to the polling message to return a data message to the first apparatus containing an indication of the value of the digital data derived at the second point; characterised in that said first apparatus utilises the data message together with a knowledge of the receipt time of the data message at the first apparatus, and the sum of the time interval between the time of monitoring by the second apparatus of the value represented by the data message and the receipt of the polling message, the time delay at the second apparatus between receipt of the polling message and transmission of the data message, the duration of the data message, and the transmission time of the data

message through the communication channel, to first determine the time said value represented by the data message was monitored by the second apparatus relative to a time at which a value of said electrical quantity was monitored by the first apparatus, and then to use the time so determined to perform a vector transformation of an electrical quantity as represented by said derived digital data so as to provide digital data representative of values of said electrical quantity occurring at substantially the same instant at the first and second monitoring points.

One differential relay in accordance with the invention will now be described, by way of example only, with reference to the accompanying drawings in which:—

Figure 1 is a graphical representation of the operating principle of the relay; and

Figure 2 illustrates the differential protection characteristics of the relay.

Referring firstly to Figure 1, the relay comprises a master apparatus 1, and a number of slave apparatus 3, situated at the other ends of a multi-ended electrical feeder 5, only one such slave apparatus 3 being shown in the figure for simplicity, each apparatus being under the control of one or more microprocessors. The master apparatus samples current signals at its end of the feeder at time intervals t_{M1}, t_{M2} etc. which are defined by a free-running clock incorporated within the master apparatus as indicated in Figure 1. The slave apparatus samples current signals at its end of the feeder at time intervals t_{S1}, t_{S2} which also need not be identical but are defined by an independent free-running clock incoporated within the slave apparatus, the sample times at the master and slave ends of the feeder not necessarily being coincident. The sampling times may even be at slightly different frequencies. The sampled current signals at each end of the feeder represent the intantaneous values of the three phase currents and the neutral current at the end, and may contain unwanted d.c. offset, harmonics, and high frequency components. The master and slave apparatus thus contain means for filtering the data, and preprocessing it to a form suitable for the calculation of the magnitudes of differential and bias currents as further described hereafter.

At required times, for example after the time interval t_{M1}, the master apparatus 1 sends a polling message down a digital data communication channel indicated as 7 to the slave apparatus 3. This polling message contains a time tag corresponding to t_{M1}, and command and status information. The salve apparatus 3 responds to the polling message by returning a data message to the master apparatus, containing the polling time tag t_{M1}, the time between the most recent slave apparatus sampling and the arrival of the polling message, the most recently filtered current data sampled by the slave apparatus, and other status information. Using the send-off time of the polling message, and the arrival time of the slave data message, the master apparatus is then able to calculate the communication channel delay time, and to time align the slave data to the master data using a vector transformation technique as described hereafter. The master apparatus then operates to protect the feeder when the difference between the time aligned current values at the two ends of the feeder 5 exceeds a predetermined value.

The one-cycle window Fourier signal processing method is used to filter and preprocess the current signals measured at each end of the feeder. The algorithm for this method can be expressed as:

$$I_s=\frac{2}{N}\sum_{n=1}^{N-1}\sin n w\Delta t\cdot i_n$$

$$Ic=\frac{2}{N}\left(\frac{i_0}{2}+\frac{i_N}{2}+\sum_{n=1}^{N-1}\cos n w\Delta t\cdot i_n\right)$$

where

N is the number of samples measured per cycle of the current signal in the feeder;

w is the fundamental angular frequency of the current signal;

Δt is the sampling time;

i_n is the instantaneous value of the current signal measured at time t_n

I_s is the Fourier sine integral of the current signal; and

I_c is the Fourier cosine integral of the current signal.

If the fundamental component of the current signal is I sin (wt+θ) where θ is a phase angle, then it can be shown that:—

$$I_s=I\cos\theta$$

$$I_c=I\sin\theta$$

As the phase angle θ is related to the time reference of the data window, I_s and I_c are not static, but are sinusoidal quantities. The phasor $I=(I_s+jI_c)$ thus represents a vector rotating in an anticlockwise direction on the complex plane at the angular frequency w, from which the magnitude of the current signal i may be extrapolated.

Assuming the master apparatus decides to send a polling message to the slave apparatus at time ta after data sampling at t_{M1}, the communication interface of the master apparatus will take some time t_b to send out the whole polling message. If the transmit channel propagation delay time is t_{p1}, then the end of the polling message will have arrived at the slave apparatus at time

$$(t_{M1}+t_a+t_b+t_{p1}).$$

The returned data message, containing the polling time tag t_{M1}, the time between the slave sampling t_{S2} and the arrival of the polling message t_{sd}, the filtered I_s, I_c data last produced by the salve apparatus at time t_{S2}, and other status information will have arrived back at the master apparatus at time t_{M^*} where

$$t_{M^*}=(t_{M1}+t_a+t_b+t_{p1}+t_c+t_d+t_{p2})$$

where

t_c is the processing time the slave apparatus takes before it starts to send off the data message;

t_d is the time the communication interface of the slave apparatus takes to send out the whole data message; and

t_{p2} is the receive channel propagation delay.

It it is assumed that the transmit and receive channels have the same propagation delay time, i.e. $t_{p1}=t_{p2}$, as t_a, t_b, t_c and t_d are all known quantities, than the channel propagation delay time t_p may be calculated from:

$$t_{p1}=t_{p2}=t_p=(t_{M^*}-(t_{M1}+t_a+t_b+t_c+t_d))/2$$

After estimating the value of t_p, the master apparatus is then able to identify the sampling time, t_{s^*} of the received slave data from the expression:

$$t_{s^*}=t_{M^*}-(t_{sd}+t_c+t_d+t_p)$$

After identifying t_{s^*}, the slave data may then be time aligned with the master data. As can be seen in Figure 1, in the particular relay being described by way of example, t_{s^*} happens to be equal to t_{s2}. The master apparatus should identify, therefore, that the slave data are sampled at a time between t_{M2} and t_{M3}, so that the slave data must be aligned to these times. Alignment to both these times is required, as this allows differential protection comparison to take place on every data sample of the master apparatus, while requiring the slave apparatus to be polled for data only once every two data samples, so reducing the data bandwidth requirement.

Using a look-up table, the parameters (a+jb) required to perform a phase shift on (I_s+jI_c) for the slave data, corresponding to the time $(t_{M3}-t_{S^*})$ may be obtained.

The phasor value of the slave current I_{S3} at time t_{M3} may then be calculated from:

$$\begin{aligned} I_{S3}&=(I_s+jI_c)(a+jb)\\ &=(aI_s-bI_c)+j(bI_s+aI_c) \end{aligned}$$

The value of the slave current at time t_{M2} can be obtained likewise by rotating I_{S3} backward by a fixed angle corresponding to the sampling time period.

Referring now also to Figure 2, if I_A, I_B, I_C, . . . are the current signals measured at ends A, B, C . . . of the protected feeder, then the differential current, I_{diff}, and the through current $I_{through}$ are defined as:

$$I_{diff}=I_A+I_B+I_C+\ldots$$

$$I_{through}=|I_A|+|I_B|+|I_C|+\ldots$$

As indicated in Figure 2, a percentage biased differential protection characteristic is used for the relay, the tripping criteria being:—

$$|I_{diff}|>k\ (I_{through}\ldots)$$

and

$$|I_{diff}|>I_{th}$$

where
k is the bias coefficient and
I_{th} is the minimum differential current value for trip protection.

The microprocessor incorporated in the master apparatus then calculates $|I_{diff}|$, $|I_A|$, $|I_B|\ldots$ from the corresponding vector components I_s, I_c using a linear approximation technique to perform the equivalent of the equality

$$|I|=\sqrt{(I_s^2+I_c^2)}$$

so as to determine from the monitored values of current after they have been time aligned whether to operate the relay to protect the feeder.

The microprocessor may be self manipulating to vary the threshold and through current settings to produce an adaptive relay characteristic for improved sensitivity and stability.

In one particular relay in accordance with the invention adopting the ISO//CCITT's high level data link control communication protocol, for the data message, the information field will suitably contain the polling time tag (1 byte), the slave sampling delay time t_{sd} (1 byte), I_s and I_c of the phase and neutral current signals (16 bytes), and status information (1 byte). The whole message frame, would therefore be 25 bytes long, have a protocol efficiency of 76%, and take about 3.75 ms to transmit through a single 64 kbps data channel. It will, therefore be possible to share the communication link with other signalling and telecommunication equipment. As only one data message needs to be transmitted for each two data samples, a suitable sampling rate would be 8 samples per cycle of the means supply, the resulting average relay operating time being about 26 ms for 50 Hz operation. It will be appreciated however that this performance represents a balance of operating speed, and communication requirement and does not represent the limit of the relay. Typically the relay will have sampling rates of between 400 to 800 per second, these relatively low sampling rates enabling the use of low cost electronic components in the relay. Faster operating times may be achieved by using wider bandwidth channels, whilst slower, more economical channels may be used for applications which do not require phase selection. It will be appreciated that any form of data communication channel may be used in a relay in accordance with the invention, such as fibre optic links, or conventional communication lines with adequate bandwidth. As the relay is microprocessor based however, a particular advantage of a relay in accordance with the invention is that it is easily adapted to work with different communication equipment by minor changes in the interfacing hardware.

It will also be appreciated that as the channel delay time t_p is calculated for each data poll, any changes on the communication channel are monitored this being particularly important where the communication time is part of a switched telecommunication network.

It will also be appreciated that as the time tag T_{M1} is incorporated in both the polling message and the data message, the time tag may be used to perform the function of a random number check on the communication and processing facilities of the relay.

It will also be appreciated that whilst in the particular relay described herebefore by way of example there is a master apparatus, and a number of slave apparatus, the invention is equally applicable to master-master arrangements in which the relay can both send a poll message and respond to a polling message at the same time. Under the master-master situation, each message will act both for polling and data transmission and will contain two time tags, one from each end, status, command, data and other timing information, such as t_{sd}, t_a, t_c. The timing information t_a and t_c are required in the master-master arrangement as the delay between the arrival of a message and the return message can be variable. Whilst such a master-master arrangement may be applicable in a two or three-ended feeder system generally, however, master-slave arrangements in multi-ended systems are advantageous as they lower the communications and processing requirements.

It will also be appreciated that each master or slave apparatus may, in itself include a means for back-up protection of the feeder. Thus in the event of the failure of the communication channel, or communication equipment, the protective equipment at the ends of the feeder may be given the option of staying idle or operating under a stand-alone mode as a form of back-up protection. For example the protection equipment may operate as an overcurrent protection relay based on the local I_s, I_c values measured.

Claims

1. A differential relay operative to protect an electrical feeder in an electrical power transmission

system in dependence on the differences in an electrical quantity monitored at different monitoring points on the feeder comprising: a respective apparatus associated with each monitoring point, each apparatus including means for deriving digital data representative of the value of the electrical quantity at the point, at time intervals defined by a respective clock within the apparatus; a digital data communication channel (7) linking the monitoring points; and means for transmitting through the communication channel (7) a polling message from a first said apparatus (1) located at a first monitoring point, to a second said apparatus (3) located at a second monitoring point, the second apparatus (3) including means responsive to the polling message to return a data message to the first apparatus (1) containing an indication of digital data derived at the second point; characterised in that said first apparatus (1) utilises the data message together with a knowledge of the receipt time ($t_{M'}$) of the data message at the first apparatus (1), and the sum of the time interval (t_{sd}) between the time (t_{s2}) of monitoring by the second apparatus (3) of the value represented by the data message and the receipt of the polling message, the time delay (t_c) at the second apparatus between receipt of the polling message and transmission of the data message, the duration (t_d) of the data message, and the transmission time (t_p) of the data message through the communication channel (7), to first determine the time ($t_{s'}$) said value represented by the data message was monitored by the second apparatus (3) relative to a time (t_{M2} or t_{M3}) at which a value of said electrical quantity was monitored by the first apparatus (1), and then to use the time so determined ($t_{s'}$) to perform a vector transformation of an electrical quantity as represented by said derived digital data so as to provide digital data representative of values of said electrical quantity occurring at substantially the same instant at the first and second monitoring points.

2. A relay according to Claim 1 in which said data message includes an indication of said time interval (t_{sd}) between said time (t_{s2}) of monitoring by the second apparatus (3) of the value represented by the data message and the receipt of the polling message.

3. A relay according to Claim 1 or Claim 2 wherein said first apparatus (1) includes means for calculating said transmission time (t_p) of the data message through the communication channel (7).

4. A relay according to Claim 3 wherein said means for calculating said transmission time (t_p) includes means for measuring the time elapsing ($t_{M'}-t_{M1}$) between transmission of the polling message and receipt of the data message and deriving said transmission time (t_p) from said elapsed time ($t_{M'}-t_{M1}$).

5. A relay according to any one of the preceding claims in which the polling message includes a time tag (t_{M1}) indicative of the time of derivation of digital data by the first apparatus (1).

6. A relay according to Claim 5 in which the data message also includes the time tag (t_{M1}).

7. A relay according to Claim 6 including means for using the time tag (t_{M1}) to perform a random number check on the operation of the relay.

8. A relay according to any one of the preceding claims in which the second apparatus (3) includes filtering means effective to preprocess the digital data derived at the second point.

9. A relay according to Claim 8 in which the preprocessing is effective to remove dc and harmonic components from the digital data.

10. A relay according to Claim 9 in which the filtering means is a Fourier filtering means.

11. A relay according to any one of the preceding claims wherein the digital data at the second point is derived only once for every two digital data derivations at the first point.

12. A relay according to any one of the preceding claims in which the electrical quantity is current.

13. A relay according to any one of the preceding claims in which each apparatus is microprocessor controlled.

Patentansprüche

1. Differentialrelais zum Schützen einer elektrischen Stromzuleitung in einem Uebertragungssystem für elektrische Leitung in Abhängigkeit von Unterschieden einer elektrischen Grösse, die an verschiedenen Stellen auf der Stromzuleitung überwacht wird; mit einem jedem der Ueberwachungsstellen zugeordneten entsprechenden Gerät, wobei jedes Gerät Mittel zum Herleiten von digitalen Daten, die den Wert der elektrischen Grösse an dieser Stelle darstellen, einschliesst und wobei die digitalen Daten in Zeitintervallen, die durch entsprechende, innerhalb des Gerätes vorhandene Taktimpulse bestimmt werden, hergeleitet sind; mit einem digitalen Datenübertragungskanal (7), der die Ueberwachungsstellen miteinander verbindet; mit Mitteln zum Uebertragen einer aufrufenden Nachricht von einem ersten Gerät (1) bei einer ersten Ueberwachungsstelle zu einem zweiten Gerät (3) bei einer zweiten Ueberwachungsstelle über den Datenübertragungskanal (7), wobei das zweite Gerät (3) Mittel enthält, die auf die aufrufende Nachricht ansprechen, um dem ersten Gerät (1) eine Mitteilung in Form von Daten zurückzuschicken, welche einen Hinweis auf die an der zweiten Stelle hergeleiteten digitalen Daten enthält; dadurch gekennzeichnet, dass das erste Gerät (1) die Datenmitteilung zusammen mit der Kenntnis ihrer Empfangszeit ($t_{M'}$) beim ersten Gerät (1), sowie der Grösse des Zeitintervalles (t_{sd}) zwischen der Ueberwachungszeit (t_{s2}) des durch die Datenmitteilung dargestellten Wertes beim zweiten Gerät (3) und dem Empfang der aufrufenden Nachricht, der Zeitverzögerung (t_c) beim zweiten Gerät zwischen dem Empfang der aufrufenden Nachricht und dem Senden der Datenmitteilung, der Dauer (t_d) der Datenmitteilung und der Uebertragungszeit (t_p) der Datenmitteilung über den Datenübertragungskanal (7) verwertet, um einerseits dei Zeit ($t_{s'}$) des durch die Datenmitteilung dargestellten Wertes, der durch das

zweite Gerät (3) relativ zu einer Zeit (m_{M2} oder t_{M3}) überwacht worden war zu bestimmen, wobei zur Zeit (t_{M2} oder t_{M3}) auch ein Wert der elektrischen Grösse durch das erste Gerät (1) überwacht worden war, um dann die so bestimmte Zeit (t_{s*}) zu verwenden, um eine Vektortransformation einer elektrischen Grösse, wie sie durch die hergeleiteten digitalen Daten dargestellt ist, vorzunehmen, um repräsentative digitale Daten von Werten der elektrischen Grösse bereitzustellen, welche im wesentlichen zum gleichen Zeitpunkt bei der ersten und der zweiten Ueberwachungsstelle hergeleitet worden sind.

2. Relais nach Anspruch 1, dadurch gekennzeichnet, dass die Datenmitteilung eine Indikation des Zeitintervalles (t_{sd}) zwischen dem Ueberwachungszeitpunkt (t_{s2}) durch das zweite Gerät (3) des durch die Datenmitteilung dargestellten Wertes und dem Empfang der aufrufenden Nachricht einschliesst.

3. Relais nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass das erste Gerät (1) Mittel zum Berechnen der Uebertragungszeit (t_p) der Datenmitteilung durch den Datenkommunikationskanal (7) einschliesst.

4. Relais nach Anspruch 3, dadurch gekennzeichnet, dass die Mittel zum Berechnen der Uebertragungszeit (t_p) Mittel zum Messen der vergangenen Zeit ($t_{M*}-t_{M1}$) zwischen der Uebertragung der aufrufenden Nachricht und dem Empfang der Datenmitteilung sowie Mittel zum Herleiten der Uebertragungszeit (t_p) aus der vergangenen Zeit ($t_{M*}-t_{M1}$) einschliessen.

5. Relais nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass die aufrufende Nachricht ein Zeitkennzeichen (t_{M1}), welches auf die Herleitungszeit der digitalen Daten durch das erste Gerät (1) hinweist, einschliesst.

6. Relais nach Anspruch 5, dadurch gekennzeichnet, dass die Datenmitteilung ebenfalls das Zeitkennzeichen (t_{M1}) einschliesst.

7. Relais nach Anspruch 6, dadurch gekennzeichnet, dass Mittel vorhanden sind, um das Zeitkennzeichen (t_{M1}) zum Herleiten einer wahllosen Anzahl Prüfungen über das Arbeiten des Relais zu verwenden.

8. Relais nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, dass das zweite Gerät (3) Filtermittel einschliesst, welche wirksam sind, um die an der zweiten Stelle hergeleiteten Daten zum voraus zu bearbeiten.

9. Relais nach Anspruch 8, dadurch gekennzeichnet, dass das Vorausbearbeiten zum Entfernen von Gleichstrom- und harmonischen Komponenten von den digitalen Daten wirksam ist.

10. Relais nach Anspruch 9, dadurch gekennzeichnet, dass die Filtermittel Fourier-Filtermittel sind.

11. Relais nach einem der Ansprüche 1 bis 10, dadurch gekennzeichnet, dass die digitalen Daten an der zweiten Stelle nur einmal hergeleitet werden für jede zweimalige Herleitung der digitalen Daten an der ersten Stelle.

12. Relais nach einem der Ansprüche 1 bis 11, dadurch gekennzeichnet, dass die elektrische Grösse ein Strom ist.

13. Relais nach einem der Ansprüche 1 bis 12, dadurch gekennzeichnet, dass jedes Gerät durch einen Microprocessor gesteuert ist.

Revendications

1. Relais différentiel destiné à protéger un dispositif d'alimentation électrique d'un système de transmission d'énergie électrique en fonction des différences présentées par une quantité électrique contrôlée à différents points de contrôle sur le dispositif d'alimentation, comprenant un appareil respectif associé à chaque point de contrôle, chaque appareil comprenant un dispositif destiné à dériver des données numériques représentatives de la valeur de la quantité électrique à ce point, à des intervalles de temps déterminés par une horloge respective incorporée à l'appareil, un canal numérique (7) de communication de données reliant les points de contrôle, et un dispositif destiné à transmettre, par le canal (7) de communication, un message d'invitation à émettre provenant d'un premier appareil (1) placé à un premier point de contrôle vers un second appareil (3) placé à un second point de contrôle, le second appareil (3) comprenant un dispositif commandé par le message d'invitation à émettre et destiné à renvoyer un message de données au premier appareil (1), ce message contenant une indication relative aux données numériques dérivées au second point, caractérisé en ce que le premier appareil (1) utilise le message de données avec une connaissance du temps de réception (t_{M*}) du message de données au premier appareil (1), et de la somme de l'intervalle de temps (t_{sd}) compris entre le moment (t_{s2}) de contrôle par le second appareil (3) de la valeur représentée par le message de données et la réception du message d'invitation à émettre, du retard (t_c), au second appareil, existant entre la réception du message d'invitation à émettre et la transmission du message de données, de la durée (t_d) du message de données, et du temps de transmission (t_p) du message de données par le canal de communication (7), afin que le temps (t_{s*}) auquel la valeur représentée par le message de données a été contrôlée par le second appareil (3) soit déterminé initialement par rapport à un temps (t_{M2} ou t_{M3}) auquel une valeur de la quantité électrique a été contrôlée par le premier appareil (1), et que le temps ainsi déterminé (t_{s*}) soit alors utilisé pour l'exécution d'une transformation vectorielle d'une quantité électrique telle que représentée par les données numériques dérivées, de manière que des données numériques représentatives des valeurs de la quantité électrique apparaisant pratiquement au même instant au premier et au second point de contrôle soient obtenues.

2. Relais selon la revendication 1, dans lequel le message de données comprend une indication relative à l'intervalle de temps (t_{sd}) compris entre le temps (t_{s2}) du contrôle, par le second appareil (3), de la valeur représentée par le message de données et la réception du message d'invitation à émettre.

3. Relais selon la revendication 1 ou 2, dans lequel le premier appareil (1) comporte un dispositif de calcul du temps de transmission (t_p) du message de données par le calcul de communication (7).

4. Relais selon la revendication 3, dans lequel le dispositif de calcul du temps de transmission (t_p) comporte un dispositif de mesure du temps ($t_{M*}-t_{M1}$) qui s'écoule entre la transmission du message d'invitation à émettre et la réception du message de données, et de dérivation du temps de transmission (t_p) de ce temps écoulé ($t_{M*}-t_{M1}$).

5. Relais selon l'une quelconque des revendications précédentes, dans lequel le message d'invitation à émettre comporte une étiquette de temps (t_{M1}) représentative du moment de la dérivation des données numériques par le premier appareil (1).

6. Relais selon la revendication 5, dans lequel le message de données comporte aussi l'étiquette de temps (t_{M1}).

7. Relais selon la revendication 6, comprenant un dispositif destiné à utiliser l'étiquette de temps (t_{M1}) pour une vérification aléatoire du fonctionnement du relais.

8. Relais selon l'une quelconque des revendications précédentes, dans lequel le second appareil (3) comporte un dispositif de filtrage assurant le traitement préalable des données numériques dérivées au second point.

9. Relais selon la revendication 8, dans lequel le traitement préalable est destiné à supprimer les composantes en courant continu et des harmoniques des données numériques.

10. Relais selon la revendication 9, dans lequel le dispositif de filtrage est un dispositif de filtrage de Fourier.

11. Relais selon l'une quelconque des revendications précédentes, dans lequel les données numériques au second point sont dérivées uniquement une fois pour deux dérivations des données numériques au premier point.

12. Relais selon l'une quelconque des revendications précédentes, dans lequel la quantité électrique est un courant.

13. Relais selon l'une quelconque des revendications précédentes, dans lequel chaque appareil est commandé par un microprocesseur.

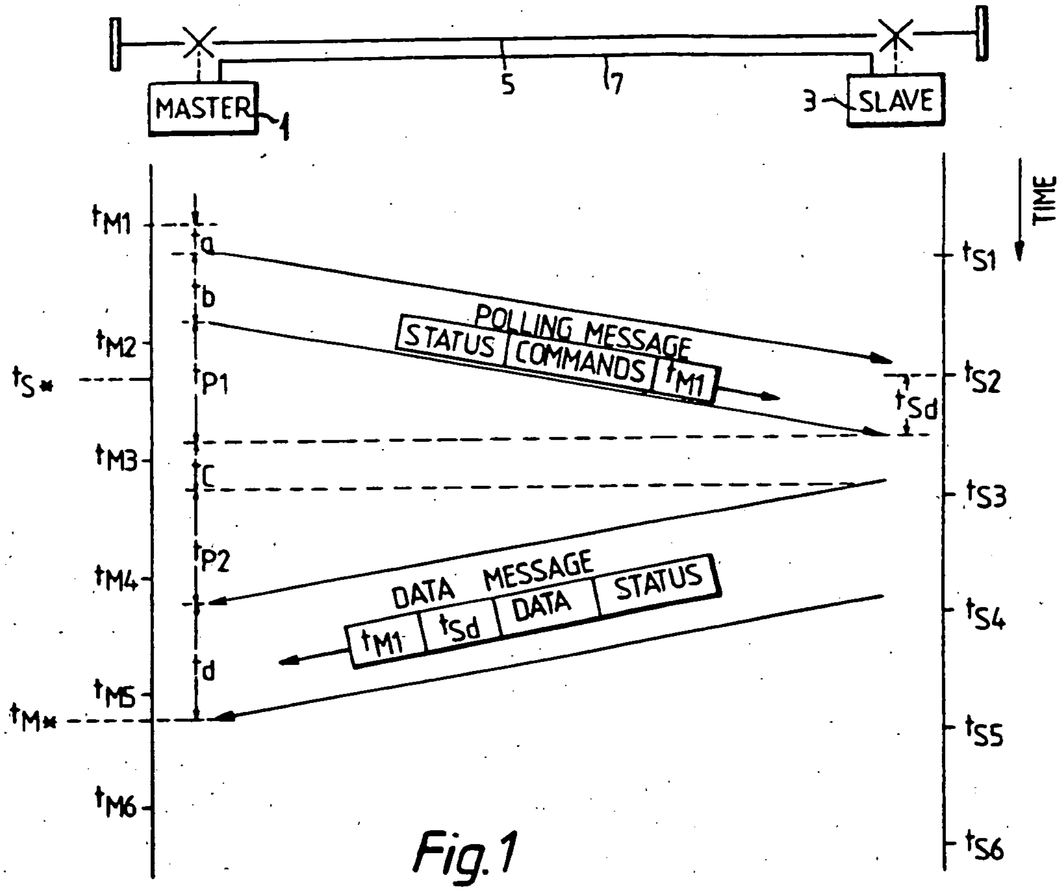
MASTER
1
5
7
3
SLAVE
TIME
t_{M1}
t_{M2}
t_{S*}
t_{M3}
t_{M4}
t_{M5}
t_{M*}
t_{M6}
t_a
t_b
t_{P1}
t_c
t_{P2}
t_d
t_{S1}
t_{S2}
t_{Sd}
t_{S3}
t_{S4}
t_{S5}
t_{S6}
POLLING MESSAGE
STATUS
COMMANDS
t_{M1}
DATA MESSAGE
t_{M1}
t_{Sd}
DATA
STATUS

Fig.1

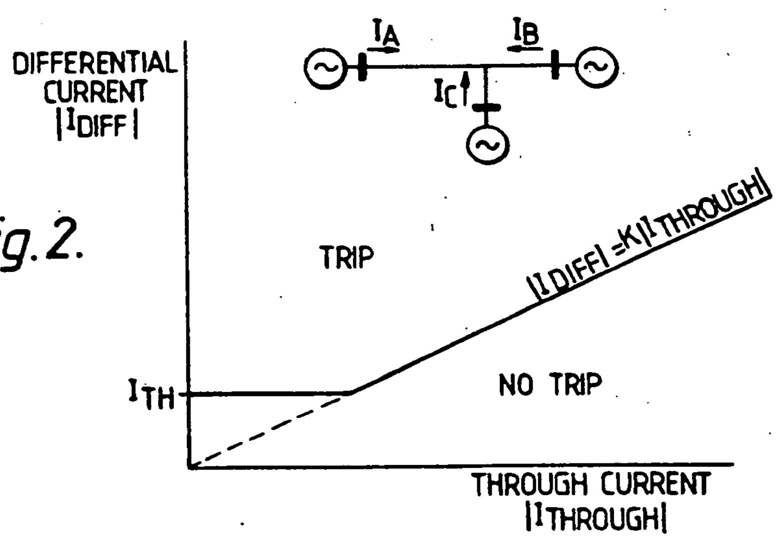
DIFFERENTIAL CURRENT $|I_{DIFF}|$
I_A
I_B
I_C
TRIP
$|I_{DIFF}| = K|I_{THROUGH}|$
NO TRIP
I_{TH}
THROUGH CURRENT $|I_{THROUGH}|$

Fig.2.

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